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West Europe Report

SCIENCE AND TECHNOLOGY

No. 35

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CONTENTS

WESTERN-WORLD RESEARCH IN COMPOSITE MATERIALS REVIEWED

Paris L'USINE NOUVELLE in French 18 Sep 80 pp 164-166

[Article by Pierre Laperrousaz and Dominique Benasteau: "Compounds Making Progress in Industry"]

[Text] By combining carbon and Kevlar fibers with each other or with glass to strengthen the "advanced" composites, by automating manufacturing processes, we are now trying to reduce the cost of composite materials. Parallel to that, research is being concentrated on the improvement of their performances, especially the new matrixes.

Nine industrial cases, six aviation industry cases, as well as the "practical application" sessions of the Third International Conference on Composite Materials reflect the evolution of this heterogeneous family. Windmills, pipes and their connections, violins, futurist houses, inertial wheels, cam shafts, or loom parts make use of the performances (lightness, rigidity) of composite substances. The most sophisticated ones are encountering growing interest for many aircraft parts, both military and commercial, helicopters, or space ships. One big customer, the automobile, also seems ready to succumb to their charms. But before that, designers and style experts will have to convince their financing sources. If they use widely differing materials, both for their base (matrixes) and for their reinforcement (fibers), the "advanced" composites have one point in common: a cost price which is generally higher than that of traditional materials. Kelvar, boron, or carbon--which have not yet been able to reach the moderate price level of glass fibers--found themselves penalized in their development. Especially outside the aviation industry. This is why one solution which is very much in vogue seems to be hybrid reinforcement where two types of fibers are combined in order to obtain an optimum performance/cost ratio. But a major effort yet remains to be undertaken. George P. Peterson, of Wright Patterson AFB, thinks that "the matrixes and manufacturing processes are the keys to the conversion of the relatively costly materials of today into low-priced structural components."

This is why epoxy-resins, and, to a lesser degree, the phenolic ones remain the materials that are most utilized in the "advanced" composites. Their tolerance of temperature (at most 160-180 °C over a long time in the case of the epoxy-resins) limits their applications. There are more high-performance resins but they are handicapped by their price and, in certain cases, by the fact that they are more difficult to utilize.

PSP Resins Competitive with Polyimides

Polyimides are used in the form of preimpregnated substances and powders for molding (Rhone-Poulenc) are used in the aviation industry and are rather timidly getting into the auto industry and into industrial parts. They "stand up" at 180 °C for a long time (20,000 hours) and can take peaks of 280-300 °C for several hours. More recently, the PSP (polystyryl-pyridine) resins, perfected 2 years ago by ONERA [National Office for Aerospace Studies and Research] and developed by SNPE [National Powder and Explosives Company], are being experimented with in the aerospace industry (missile parts, radomes) in the form of preimpregnated carbon fiber. Their resistance to temperature over a long time is 250 °C with the possibility of peaks at 400 °C. This comes on top of good resistance to fire and low fume emission. Their price has come down somewhat (F 100-150 per kilogram); they are now becoming competitive with respect to the polyimides and the SNPE is at this time developing molding powders which could very well find use in automobiles. Other resins, such as the phthalocyanines (aromatic nitrile) at the Naval Research Laboratory, Washington, have not yet gone beyond the laboratory stage. Their temperature resistance for long periods of time is satisfactory up to 250 °C.

Another category of advanced composites seems to have serious prospects in the immediate future. These are the carbon-fiber-reinforced industrial thermoplastics such as polyamide, polysulfone, polyester, PPS (phenylene polysulfide), polycarbonate, etc. According to Courtaulds, they have been progressing at the rate of 50 percent per year since 1974. In 1980, world-wide consumption will be 12 t and estimates for 1985 run toward 500 t! This success is explained by a "cocktail" of interesting properties: resistance to high bending and traction, very great rigidity, good thermal and electrical properties, slow heat dilation, and low friction coefficient. Among some examples of practical applications (some of which already took place in the industrial stage and were mentioned by Courtaulds) we have the following: a small roller for a molded control lever consisting of polyamide 66 with 30-percent carbon fibers, previously machined in phosphorous bronze (it held up under more than 3.5 million cycles in the course of laboratory tests); a rotor prototype for a diesel turbocompressor being tested by Courtaulds, in Great Britain (the pallets, traditionally made of aluminum, consist of PPS or polyethersulfone reinforced with 30 percent carbon fibers and turning at 100,000 rpm at temperatures of 120-130 °C).

The thermoplastic-carbon fiber composites are employed by means of injection on conventional, automatically controlled machines; they can thus be used for high production rates. On the other hand, the heat-hardenables still require a large number of skilled workers and long oiling times. Now, according to an American specialist in the aviation industry and in the case of preimpregnated substances, the automation of cutting, draping (placement of preimpregnated folds into the mold) and transfer could reduce the manufacturing time by 80 percent. General Dynamics, Northrop, and Grumman all have projects of this kind in progress, thus opening the way for other sectors, such as the auto industry. Development of semi-finished products--(preimpregnated or not preimpregnated) fabrics with oriented woof, powder-extruded [pultrudes] section pieces--is also one way toward higher productivity. At Toulouse, the ONERA has managed to improve the output of "pultrusion" [powder extrusion] by using microwaves for the "in-line" polymerization of powder-extruded section pieces. The latter, heated to the core, present a more homogeneous structure; tests conducted by Aerospatiale, with a view to their utilization in helicopter blades, showed that their performances exceeded those listed in the specifications. Rolling up filaments, to make semi-finished or finished pieces, is also a promising technique. Control by means of the microprocessor today provides great flexibility for this method; highly complex revolving pieces can be produced according to specific roll-up programs inserted into the machines by means of an alphanumerical keyboard.

Filament Roll-up--A "Simulation Bench"

Machines of this type are being built in France by Plastrex-Manurhin and in the United States by McClean Anderson. At the latter establishment, programming is possible also by means of a lever with three degrees of freedom. For the manufacture of pieces without rotation symmetry (a T-shaped tubular connection, for example), the IKV (Synthetic Substance Processing Institute) at Aachen has perfected a special programming device. This is a "simulation bench" (to some extent, a reduced-sized mockup of a windup machine) which is operated by hand, according to four degrees of freedom, in order to "roll up" a given piece also represented by a mockup. All of the movements are recorded in a digital form and are inserted into the production machine.

Composites with metallic matrix, which constitute a class somewhat by themselves, compare favorably to alloys coming from the same base material. Compared to their cousins, with the resin matrix, they have more worthwhile performances in terms of heat conductivity, according to The Aerospace Corporation. Other properties are also improved, according to Lockheed Missiles and Space Company, which experimented with reinforcements consisting of alumina, graphite, and silicon carbide. Module and resistance in the lateral direction are particularly increased in the case of aluminum-alumina composites. In the case of carbon or silicon carbide fibers, a

bad connection between the matrix and fiber seems responsible for a certain variation between the longitudinal and transversal performances. Other studies conducted in Japan (alu 5056, reinforced with carbon), at high temperature, evidenced ruptures due to the weakness of the connection on the level of the joints of the matrix grain. Resistance in the longitudinal direction reveals a decline up to 450 °C and a drop at 550 °C.

Another promising family--composites with an aluminum matrix reinforced with glass fibers--appear essential for the structures of future missiles at MBB (Messerschmitt, Boelkow, Blohm) and German Aviation and Space Research and Experimental Institute. This is true in spite of the very high cost of fiber production. But, due to mechanical performances and due to resistance to aggressive environments, as well as fire, this obstacle is being overcome. For high temperatures and in an oxidizing atmosphere, the "all-carbon" materials were perfected. According to the solid chemistry laboratory of the CNRS [National Center for Scientific Research] and the European Propulsion Society, tests on carbon composites linked by a SiC matrix have an elastic performance under compression almost up to rupture. Resistance at 1,500 °C is guaranteed for long exposures and even at high temperatures for short durations. These composites are derived from 2 d carbon/carbon and are obtained from predensified preforms whose residual porosity is saturated by SiC.

The assembly of "sheets" of composites necessitates certain precautions. The Imperial College of Science and Technology in London, after some trial and error, spelled out rules for assembly without problems regarding plastic substances reinforced by carbon fibers. The minimum thickness for riveting seems to be 0.5 mm. The material proved to be definitely more sensitive to discontinuities than a metal; punching and riveting must be performed carefully. Full rivets are preferable over hollow ones and flat-heads are preferable over milled heads. For the latter, an angle of 120° should be selected, rather than 100°. For pipes and sheets employed in structures which subject them to axial loads, connections using adhesives limit the design. According to Fulmer Institute and RAE Farnborough, they are sometimes more worthwhile than mechanical assembly but another solution looks better: it involves assembly pieces which permit the lineup of the tubes. Threading and glueing are combined to obtain a light and effective assembly at a reduced cost.

Here is another difficulty: the behavior of fibers, for example, in a given environment, does not necessarily reflect that of the "complete" composite. This is one of the conclusions deriving from a test program at the Bouchet research center of the SNPE. Kevlar 29 or 49 fibers proved their strength against a saline mist, ocean water, solvents, or grease. In humid conditions, the action on the fibers is weak. Regarding composites, it remains moderate but depends on the resin used. On the other hand, the

cycling tests on the rovings, and on composites, clearly show the stability of resistance to traction. The properties thus are not affected by exposure to temperature.

The environment is not the only factor in aging: the notion of corrosion under stress seems as important for the composites as for the metals.

Rupture Conditions: Four Stages Identified

At the University of Surrey, priority is being given to initiation with respect to propagation. Working with glass-fiber-reinforced polyesters, it was observed that the longest cracks grow most slowly. Their propagation would seem to be governed by a chemical attack mechanism of the diffusion type. At the University of Liverpool, the conditions for the rupture of these materials due to corrosion under stress and under deformation were analyzed with the help of conventional or electronic sweep microscopy. Here, four distinct stages were identified in deformation and rupture. This latter phase seems associated with the rupture of fiber. Two other laboratories at the universities of Washington and California studied the long-term behavior of composites, using data available over a period of 8 years for Kevlar/epoxy and glass/epoxy. For the latter, the manner of rupture does not seem to depend on the stress level whereas in the case of Kevlar 80, beyond 80 percent of rupture resistance, it would seem to be connected with initial defects. Below that, even at a high temperature, we are instead dealing with fatigue.

Composites Also for the Disadvantaged

Filament windup was selected as the method most suitable for building a housing unit by GA Patfoort, of the National Hoger Institut Voor Bouwkunst Stedebouw. As part of a UNIDO program, it redesigned a house as a space to live in and to get rid of the concept of walls and roofs. Result: 15-m^2 modules with a "tunnel" configuration, weighing only 250 kg. Assembled, they form housing units covering an area of 60 m^2. The rollup of polypropylene fibers or any natural fiber is accomplished manually on models made of wood and ordinary steel section pieces. The procedure is so simple that future occupants need only some strong arms to carry the modules to the site. At the ends, reinforcements serve as locks. As for the portions cut off during the assembly of the modules, they are recovered to make up the furniture. The first experiments, particularly in Ecuador, were satisfactory both for the inhabitants and from the money viewpoint. Compared to traditional construction, these futurist homes for poor regions of the world require only 1/100 of the material and 1/200 of the energy usually employed.

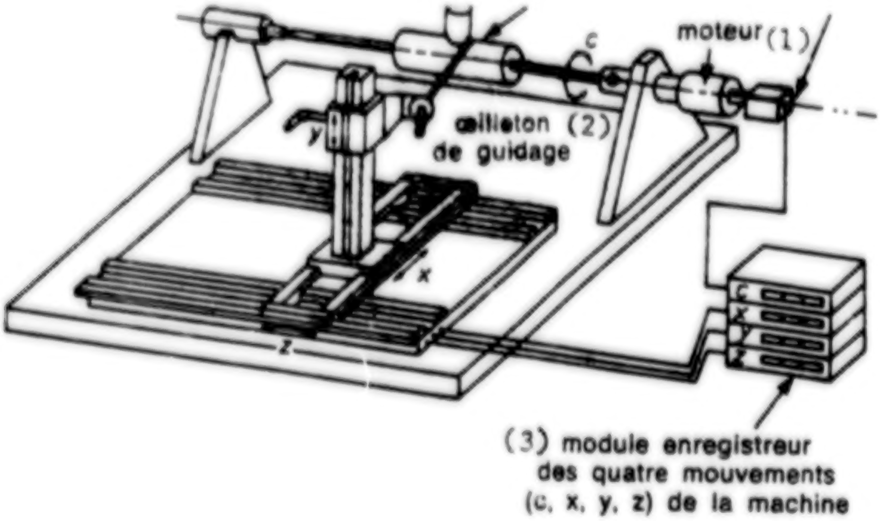
PHOTO CAPTIONS

[p 164] Windmill blades made of composite materials during construction at the Lewis Center of NASA.

[p 165] The electron-microscope reveals the manner of rupture for these two samples of glass-epoxy fibers. On the left (A), looking at the control, the resin still sticks to the broken glass fibers whereas on the right (B), after immersion for 96 hours in boiling water, adhesion between the fibers and the matrix is very poor.

[p 166] Control by means of microprocessor makes it possible to produce complex pieces by filament rollup (here accomplished manually by a control lever. McClean Anderson).

FIGURE APPENDIX



This test bench "manufactures" a mockup of the piece but it produces above all digital information on the necessary movements which will have to be inserted into the real manufacturing machine. P: 1--motor; 2--guide eyelet; 3--module recording the four movements (c, x, y, z) of the machine.

5058
CSO: 3102

PLASTICS EXHIBITION PRESENTS ADVANCES IN COMPOSITE MATERIALS

Paris L'USINE NOUVELLE in French Supplement SPECIAL TECHNOLOGIES 1980 pp 108-110

[Unattributed article: "Plastics are Changing"]

> [Excerpts] New grades of polyamides, polycarbonates, ABS, thermoplastics of the aromatic polyester type--but also a better surface appearance of these lighter substances and the general use of mold computation.

Kunstoff 79 [1979 plastics exhibit] was the big event of the year in the field of plastics and their processing. Several polyamides were included among the new products introduced on that occasion: a variety with high shock resistance (twice that of a standard PA) from Bayer, a super-rigid, reinforced polyamide with 30 percent carbon fiber from Ato (its bending module extends from 8,000 to 12,000 MPa), a polyamide with elastomeric properties from Emser Werke, and two new items from Rhone-Poulenc: one of them was characterized by its fire-resistance (VO) obtained without any halogenated additives, while the other one is used for light-substance molding, permitting production rate gains of 50-300 percent compared to the compact material.

There were also some new varieties of polycarbonate: a polycarbonate with a very much improved scratch-resistance for use in vehicle windows (Bayer) and, from that same company, a variety with antistatic properties and another one with a very high Vicat point (180 °C instead of 154) and with improved resistance to hydrolysis for the food industry. Ato also presented its Orgalan, a polycarbonate imported from Japan.

Two companies introduced a new variety of aromatic polyester (a thermoplastic). Bayer proposed three trial products characterized by a Vicat point of 185-186 °C and Solvay came out with a polyarylate, called Arylef, of Japanese origin, characterized by its dielectric properties, its temperature resistance, and its folding resistance.

Looking at ABS, PCUK came out with two new types. There is one grade (RT) which combines relatively high temperature resistance (98 ^{o}C for the deflection temperature under a load of 1.85 MPa) with a nevertheless very good Izod shock resistance (270-320 J/m) at the expense of a weaker temperature resistance (94 ^{o}C). For the second grade (MD), on the other hand, there was less sacrificing of the shock resistance (280-360 J/m).

PCUK had already, during the year, introduced an ABS protected by a film of PVDF (polyfluoride of vinylidene) with a thickness of several microns. The method can also be applied to other thermoplastics (PVC, polycarbonate). The PVDF film is coextruded with the ABS plate which is then heat-shaped to make, for example, car body parts. The very low permeability of PVDF to oxygen considerably improves the protected material's aging resistance; after 1,000 hours of exposure to Xenotest 450, the shock resistance of ABS dropped only 20 percent. Better still if PVDF contains anti-UV filters (mineral charges, pigments), the protection is even further improved and the drop is no more than 10 percent.

Range of Light Polyamides

These polyamides from Rhone-Poulenc, reinforced or not reinforced by glass fibers, enable us to obtain parts whose lightening rate, adapted to each particular application, can come to as much as 40 percent. This brings about not only a material saving but a production rate gain of 50-300 percent compared to the light amorphous materials. One can thus make many pieces so far inaccessible to compact polyamides: parts with large dimensions, massive parts or pieces involving major thickness differences. There are many possible field of application: office equipment (calculating machine cases, telex foundations and supports), the auto industry (fan case, panes), mainterance (tank or vat, maintenance table), furniture (patio furniture).

These materials can be transformed on the basis of three types of material: the traditional injection press, the "special light" injection press, and the two-material press. The expansion technique, using inflation agents, leads to a fine and homogeneous cellularization which enables us to optimize the characteristics of the basic polymer: mechanical resistance, rigidity, shock resistance, as well as temperature resistance which permits finishing with epoxy paint in a fluidized bed with heating of the part and passage to the tunnel furnace at 180 ^{o}C.

Super-Rigid Polyamides

These three qualities of polyamides reinforced with 20 or 30 percent carbon fiber or carbon fiber plus glass fiber, perfected by ATO-Chemical, present rigidity characteristics similar to those of other customary materials but

with a definitely less high density. In the aviation industry, they can replace certain light alloys for casing supports, components for the landing gear, etc. The auto industry is also interested because it is trying to reduce the weight of cars. In the machine-building sector, the replacement of heat-hardenable metals and resins is in progress. The fields of electricity, electronics, sports, and leisure are also concerned here.

These materials are injection-molded. To the qualities inherent in polyamides we can add improved physical-chemical properties as compared to polyamides combined with glass fiber. Traction resistance is slightly greater; the bending (rigidity) elasticity module, from 8,000 to 12,000 MPa, is as much as four times greater and shock resistance is equivalent; the creepage resistance index is higher and the temperature deformation under load remains the same. These materials resist bases and saline solutions, ocean water, greases, and petroleum products.

Surface Quality Improved

There is one big novelty in polyrethanes: the preimpregnated substances disclosed by Bayer. This new material comes in the form of a sheet between two films of polyethylene which can be kept at ambient temperature for several years. For its production and its processing, German engineers, to the degree possible, imitated the conventional preimpregnated substance production and processing techniques. Molding is done by compression at 125-130 °C, with the same tools as for polyester. Reinforced with 30 percent glass fiber at a length of 4-5 cm (with mineral charges moreover), the elasticity module reaches 5,000 MPa.

The surface quality of light materials is improved due to a method developed for industrial use by Structair at La Cluse (Ain). Its principle, based on a technology developed at a research center in Sofia, in Bulgaria, consists of preventing the bursting of gas bubbles forming within the expanded matter, against the walls of the mold, which gives the well-known rough appearance of the surface of parts made of light substances. For this purpose we use a nitrogen counterpressure (15-20 bars) in the mold which has been made air-tight. Then, when the mold is filled and the skin has become jellified, we allow the gas to escape which we then recover and we extract a portion of the substance from the core of the piece which has not yet become solid by means of one or several piston pots connected to the mold. The density of the material is a function of the quantity of matter extracted and then reinjected into the following cycle. The first tests involved polystyrene, polyolefins, ABS, and Noryl, as well as polycarbonate.

5058
CSO: 3102

EUROPE'S FIRST EXPERIMENTAL SOLAR FARM BUILT

Bern TECHNISCHE RUNDSCHAU in German 12 Aug 80 p 3

[Text] Solar power stations with dispersed concentrating reflectors produce heat between 150 and 400 degrees C with an efficiency of 50 percent and yields between 100 and 10,000 kW. A subsequent transformation into electrical energy achieves an overal efficiency of up to 15 percent and yields between 25 and 2,000 kW. Thermal energy is used in agriculture and industry, for example, in the production of food, textiles, paper, chemicals, for drying, sterilizing, pasteurizing and distilling. There is also some interest in the electrical energy, principally for small plants in rural or remote regions.

Economically competitive solar process heat in the medium temperature range, between 150 and 400 degrees C, can be produced in 5 to 10 years. Ten to 20 years must be allowed for the economical production of electrical energy.

The German M.A.N. company and the Spanish concern Auxini have together set up an experimental solar farm in Getafe (Madrid) with the support of the Ministry for Research and Development in Bonn and INI in Madrid. This experimental station, the first in Europe, is for the continuing development of solar energy collectors, components and systems in the medium temperature range.

In its present state of completion, the plant can generate a 250-kW thermal output (at 300 degrees C) or a 36 kW electrical power yield. The important components of the plant are:

--a collector field with three different types of collector construction (total are 580 m^2)

--an energy storage facility with three tanks (36 m^3 total capacity)

--a plant for the conversion of thermal to electrical energy with a new steam engine design based on the screw compressor

Each collector has a cylindrical reflector of parabolic section. The reflector concentrates the direct rays of the sun on an absorber pipe at

the focus of the parabola. Thermal oil flows through the inside of the pipe and conducts the heat energy to the storage facility or directly to the heat exchanger (thermal oil-water), which generates steam at 300 degrees C. The steam can then be used directly in heat processes or to drive the screw engine which is coupled to the generator.

At the start of development there was no way of predicting whether a single type of collector would be practical for all applications, or whether different types would be more cost-effective. So the joint development of the CTF 1 collector by M.A.N. and of the CTF 2 collector field by Auxini was planned.

The CTF 1 collector has an area of 150 m^2 and is mounted on a circular track, so that it can automatically follow the sun's azimuth. Elevation can be altered in single steps.

The CTF 2 collector field has six horizontal rows with an area of 240 m^2. Each row tracks the sun's elevation automatically by rotating about its horizontal axis (Photo 1).

The third type of collector (Helioman 3/32) was built by M.A.N. and has been under test in Getafe since 1979. Each module has a surface of 32 m^2 and generates 32 kW thermal yield at an outlet temperature of about 300 degrees C. It is rotated about two axes by solar sensors to track the sun automatically. This collector is also being used at the IEA solar farm in Almeira (Photo 2).

The propeller expansion machine has been specially developed for the harnessing of low temperature heat in the 200 to 300 degree C range. In the yield range between 30 and 300 kW systems like this are superior to turbines or piston stem engines because of their high efficiency, simple construction and good partial load performance. Steam drive makes no great demands on work supervision and plant maintenance. Besides their use in solar plants, low temperature circulation systems with screw engines are a good possibility for the utilization of waste heat.

The entire solar farm in Getafe is monitored from a switchboard, from which all subsystems can be controlled manually or automatically. An 18,000 m^2 site was laid out with roads, test facilities, offices and shops for the installation and testing of the whole plant. The data processing center there is linked directly to a computer and a data storage system. This allows the test team to evaluate measurements immediately and to compare the data with the precalculated figures.

A first solar farm for the industrial use of solar process heat has already become reality in Spain.

Photo 1. Collector field with horizontal parabolic cylinder collectors (foreground) and heliomaned (background). (Photographs: M.A.N., 8900 Augsburg)

Photo 2. Three of the six "Helioman 3/32" collector modules.

9581
CSO: 3102

SWEDEN

USE OF TAR AS FUEL FOR BLAST FURNACES STUDIED

Stockholm NY TEKNIK in Swedish 24 Jul 80 p 10

[Article: "'Worthless' Tar Burned in Blast Furnace"]

[Text] Tar wastes from the coking plant in Lulea could replace up to two million kronor's worth of oil per year as a fuel source for their blast furnaces. A special committee is studying the technical feasibility of replacing oil with tar or inexpensive coal.

Presently 25-35 kg of fuel oil are required to produce one ton of raw iron, according to the trade magazine Svensk Stal.

Oil is pumped into the blast furnace and burned. Hot gas builds up and is forced into the furnace where the ore is smelted down into raw iron.

Ninety Percent Coke

The main energy source in the production of raw iron is still the coke which is fed into the upper part of the blast furnace, supplying approximately 90% of the energy.

To produce one million tons of raw iron, nearly 25 million kronor's worth of fuel oil is required. These costs will be cut by replacing oil with cheaper coal or tar.

During the 1960's an attempt was made to use dry blown coal powder instead of oil. But since oil was cheaper then, coal powder was abandoned even though it worked well.

Coal Powder

The North American Steel Company Armco has used coal powder in one of its blast furnaces since 1966. In the early 1970's Armco converted another blast furnace to coal powder. But at SSAB [Swedish Steel Co] in Lulea, oil could be replaced with tar or tar sediment.

The coking plant in Lulea disposes of about 30,000 tons of tar sediment as biproducts. Tar sediment today is good for nothing except the waste pile. If instead it is used in the production of raw iron it would replace 1.5 - 2 million kronor's worth of oil per year.

9396
CSO: 3102

NEW PROCESS FOR SOLAR-GRADE POLYCRYSTALLINE SILICON

Essen ELEKTRO-ANZEIGER in German No 14, Jul 80 pp 5-6

[Text] Workers at the Laboratories d'Electronique et de Physique appliquee (LEP) in Limeil-Brevannes, France, in close cooperation with Philips international research, have discovered a method of coating a carbon substrate with polycrystalline silicon. This material is suitable for the production of solar cells for land-based applications. The efficiency of the cells is current 7 to 8 percent.

The process was developed in cooperation with Carbone Lorraine and with support from the Office of Solar Energy and the EEC commission. The Office is also funding a research project presently being conducted by LEP, which is investigating the most economical and technically optimal structure of solar cells manufactured from the material described here.

In the method developed at the LEP and shown in Figure 1, a graphite ribbon C, which acts as a base, is drawn up through a crucible K filled with molten silicon. The base of the crucible is provided with a slot. A layer of polycrystalline silicon is precipitated on the graphite ribbon, which is 1 to 3 m long and about 3 cm wide.

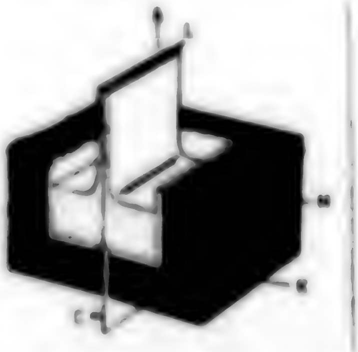


Figure 1. Coating a graphite ribbon with polycrystalline silicon in a crucible with a slotted base. The graphite ribbon C is drawn through the crucible with the molten silicon. A layer of polycrystalline silicon is deposited on both sides of the ribbon. K: slotted quartz crucible; L: polycrystalline layers; C: graphite ribbon; M: graphite casing for even heating of the crucible.

The thickness of the coating can be adjusted to between 0 and 100 m, pull-up speed can be as high as 12 cm/min.

This new method of manufacturing polycrystalline silicon coating, which is still in the experimental stage, is comparable to the classical Czochralski process for the production of single crystals, in which a seed crystal is brought into contact with the surface of a melt of the matieral from which the crystal is to be produced. If the seed crystal is then drawn up slowly, under favorable conditions it grows to become a single crystal. In the manufacture of polycrystalline layers the pull-up speed is much higher than in single crystal generation; in addition, a thin silicon coat is obtained in a single step on a conductive substratum, which avoids the cost of additional processing and the loss of material associated with it.

Solar Cell Manufacture

In order to manufacture solar cells from the polycrystalline silicon ribbon, an N+P transfer is created by a diffusion process in the silicon. The carbon base serves as the rear contact for the solar cell. Figure 2 shows the volt-amperage characteristic curve of a solar cell made from the material described.

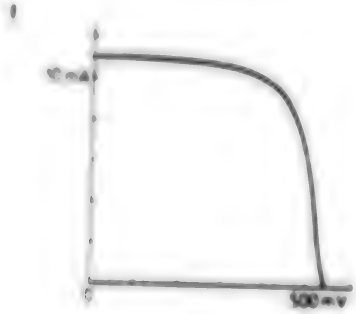


Figure 2. Volt-amperage characteristic of a polycrystalline solar cell at standard illumination; this corresponds to vertical solar rays at sealevel. Cell surface area: 0.47 cm^2

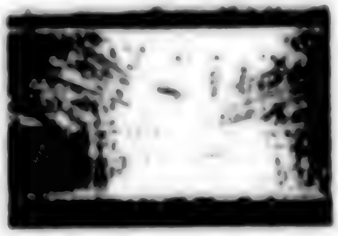


Figure 3. Photograph of the polycrystalline coat on a graphite ribbon. The width of the ribbon is about 3 cm, total maximum length 3 m. (Factory photographs: Philips)

9581
CSO: 3102

REPORT ON INDUSTRIAL TECHNOLOGY IN ELECTRONICS INDUSTRY

Essen ELEKTRO-ANZEIGER in German No 14, Jul 80 pp 14, 16

[Text] Frankfurt am Main, 7 July 1980--In January 1980 the FRG government ratified the promotional program entitled "Production Technology" containing funds totaling DM250 million up to 1983. The program, in the words of Minister for Research Hauff, is to assist in overcoming the thrust in innovation in production technology which can be expected in modern semiconductor technology. The working group for production technology at the Central Association for the Electrotechnical Industry (ZVEI) has now presented a study entitled "Production Technology in the Electronics Industry." The study describes the present unresolved problems in production technology and from this derives the main areas worthy of being promoted. Similarly, the conceivable developments in the next 5 to 10 years are treated with consideration given to the limits of technical, technological and economic possibilities and to the special problems of small and medium sized companies.

For the electronics industry, with its multifarious production sectors from electrical energy technology to measurement, control and regulator technology, to information technology and microelectronics, the development of production technology has become important for the usage of modern technologies in internal production processes as well as a shoring for companies in many other industrial branches. The study shows that research and development efforts have to be undertaken, especially in those fields in which technical and scientific innovations will be made. The economic risks for individual companies would be too great otherwise. This especially applies to small and medium-sized companies which not only lack the necessary personnel and financial means but also lack information and specific knowhow.

The ZVEI believes that for a country poor in raw materials such as the FRG it is indispensable that such technical factors be considered. Only in this way can the competitiveness of the FRG be maintained on the world market and jobs secured over the long run.

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STATUS, FUTURE OF ALTERNATE-ENERGY R&D

General Comments on Energy Expenditure

Paris ELECTRONIQUE ACTUALITES in French 12 Sep 80 p 4

[Text] France, which devoted F 1 billion in 1980 to the development of new energies, will increase its effort in 1981; in particular, a proposal will be submitted to parliament to increase the COMES (Solar Energy Commissariat) budget--which is currently F 140 million--by half.

Reviewing the situation regarding new energies in addressing the cabinet at the end of July, Industry Minister Andre Giraud indicated that, 2 years after the establishment of COMES, the policy aimed at developing new energies has entered an operational phase.

Decisive progress was made especially in the field of solar energy, the use of firewood, and geothermal sources.

The use of solar energy in the residential sector and the tertiary sector seems to have become quite the fashion since 40,000 new solar water-heaters were ordered this year against an available volume of 20,000 units. Various actions were likewise undertaken to develop solar heating and architecture through the Ministry of Environment and Human Ecology with a view to the construction of 30,000 solar houses per year between now and 1985.

The contribution from firewood to the energy assets should rise from 3 million TEP in 1976 to 4.5 in 1985 and close to 6 [millions] in 1990. This presupposes a gain of an additional 300,000 TEP per year from firewood between 1981 and 1985. In other words, firewood resources will have to be increased especially through the development of mechanization in forest exploitation.

The use of geothermal sources developed in 1980 with about a dozen operations involving more than 30,000 housing units and about a score of supplementary operations are planned for 1981.

For the future, a certain number of research and experimentation programs has been planned or is in progress. These programs in particular deal with solar power plants, the photovoltaic plan (direct production of electricity from the sun), wind energy, the biomass, and fuel alcohol.

Close to 20 biomass energy upgrading experiments are already under way. They also involve the combustion of dry substances (firewood and kindling wood, cut straw).

Other ways of converting biomass energy are being explored through research programs, the objective being to produce liquid or gaseous fuels. In this regard, methanol was selected by COMES experts as being preferable to ethanol, for use in long-range terms as liquid fuel, either pure or in a mixture.

Parallel to these research efforts, other experiments are in progress; a certain number of vehicles belonging to EDF [French Electric Power Company] and the Post Office, running on mixtures of 10 or 15 percent methanol, will be tested, according to Mr Giraud.

Furthermore, a general program for the development of new energy sources in the DOM-TOM [Overseas Departments-Overseas Territories] is being studied. It includes three aspects: an inventory of renewable energy resources, a follow-up study on past or current efforts, and experimentation with new techniques for use in housing.

We recall that, according to the objectives established by the government last April, new energy sources will have to account for 5 percent of French energy consumption by 1990, in other words, 10-12 million TEP. Most of that will come from the biomass (7.5-9 MTEP); solar heating will represent 1.3-1.5 MTEP and geothermal sources will account for 0.8-1 MTEP.

New Energy Source Policy Announced

Paris ELECTRONIQUE ACTUALITES in French 12 Sep 80 p 4

[Text] The minister of industry released an announcement on the development of new energy sources which will be expected to make a major contribution to France's energy supply. The objective established during a restricted cabinet meeting on 27 March 1980 for the year 1990 represents the equivalent of 10-12 million tons of petroleum. With water power, renewable energy sources will cover 10 percent of France's energy needs by the end of the decade.

Established 2 years ago, the Solar Energy Commissariat has carried out the first phase of its mission under excellent conditions, including research

programs and spelling out the major guidelines for the solar energy development effort. Today it is necessary to strengthen its structure and the impetus of its solar activities.

Solar policy, based on efforts made within the national plan, must also be based on the initiative of local organizations, departments, and communities, which have an essential role to play. Several agreements were signed along these lines by the Solar Energy Commissariat with these groups and organizations.

In 1980, the development of new energy sources will be expressed by an investment of F 1 billion, plus research work.

Decisive progress was made in 1980 in three sectors where technologies have been well mastered by French industry: solar heating (the number of solar panels is to be tripled during the year), the use of firewood and geothermal sources. The fast pace of development of these applications which has already been reached is going to be doubled in 1981.

Parallel to this, the research and development programs launched, especially the Themis power plant, the solar power plant in Corsica, and the photovoltaic plan (direct production of electricity from the sun) are being carried out according to schedule.

The minister of industry finally submitted the entire complex of research studies and expert reports pertaining to the use of biomass resources (utilization of agricultural products to produce energy) in the form of liquid or gaseous fuels. These studies are of essential importance because success in them will in the long run make it possible considerably to reduce the French transportation system's vulnerability to petroleum supply difficulties.

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TRANSPORTATION

FIRST FLIGHT, PROSPECTS OF 'MICROJET' ASSESSED

Paris SCIENCES ET AVENIR in French Aug 80 pp 12-13

[Article: Microjet's First Flight"]

[Text] Will lightweight jet-powered aircraft eventually supplant propeller-driven aircraft? Considering the current price of the least expensive small two-seater aircraft--approximately 150,000 francs--this is a doubtful possibility, to say the least. As is the case with automobiles, increased experience has made it possible to lower prices. But there is still a counteracting aspect, namely the fact that the slightest innovations triggers, more often than not, a rejection phenomenon, because the technical and industrial risk such innovation involves is frightening to some people. Furthermore, the smallest turbojet engine alone is already more costly than the most modest aircraft despite the gas turbine engine's apparent simplicity when compared with a reciprocating engine. Factors contributing to this price differential include: the use of noble metals capable of withstanding high temperatures, the need to very carefully machine and balance compressors and turbines spinning at several 10,000 rotations per minute, and lastly the relatively low number of engines produced. In short, it was heretofore deemed impossible to reduce an aircraft's dimensions below those of a military two-seater trainer, the standard example of which was long considered to be the Fouga Magister employed by the Patrouille de France [French Air Force aerobatic team]. But the Fouga Magister weighs nearly 3 tons and is powered by two 450-kilogram-thrust turbojet engines. f it now had to be produced again, it would cost definitely more than 1 million dollars, i.e. 4 to 5 million francs.

However, the Microjet-200's first flights at Toulouse in late June and early July have prompted reconsideration of this problem. The M-200 is a small twin-engined jet aircraft--wingspan of 7.6 meters and length of 6.12 meters--with an empty weight of 600 kilograms and a gross weight of 1,000 kilograms. The flight instructor and his student are seated side by side but in staggered position, under a semipanoramic canopy. Between them are two "mini-control columns": one is the pilot's and, therefore, right-handed, the other is left-handed. On the side are (electric) control levers for the retractable landing gear, wing flaps, and two small TRS-18 turbojet engines, each developing a static thrust of 110 kilograms (125-130 kilograms in a later version). The Microjet-200 is equipped with the latest word in thrust reversers to help in slowing down the aircraft on landing.

This small "racer"—relatively speaking, for given the scale of the aircraft, the impression of speed is altogether extraordinary--has a cruise speed in excess of 450 kilometers per hour and a maximum speed of more than 500 kilometers per hour. It has a takeoff distance of 500 meters, a 10 meter per second rate of climb, a ceiling of about 30,000 feet (altitude of 9,000 meters), and a maximum effective range of 1,000 kilometers. Twice as fast as a single-engined propeller-driven aircraft of the same weight, the Microjet-200 is the embodiment of a real change in the training activities for which it is currently designed, namely primary flight and navigational training and combat proficiency training (including aerobatics). In fact, the aircraft is proposed by its builder. Microturbo, as a missing link between the propeller-driven aircraft used to select students for military pilot training and teach them the first rudiments of flying, and the modern single-engined or twin-engined jet trainer which weighs 3 to 5 tons and actually constitutes, as things stand today, a small combat aircraft.

Flying these modern jet trainers--of which the French-German Alpha Jet is the "top of the line"--is very expensive. To such a point that rising oil costs, inter alia have compelled all air forces to reduce the number of flying hours allotted to training, a situation that ultimately poses insolvable problems. Because the Microjet-200 is two to three times lighter and consumes three to five times less fuel, it would obviously constitute a small revolution. There is already support within several general staffs for a truly lightweight jet-powered aircraft capable of being used whenever current semiheavy aircraft are not absolutely indispensable.

A civil version of such an aircraft is obviously not yet capable of competing from an economic standpoint with propeller-driven aircraft. In an average production run of 200 aircraft, the price of each Microjet-200 would come to 350,000 to 400,000 dollars, or 1.5 to 1.7 million francs. This is expensive for even a high-performance two-seater. But if the military trainer version really finds a substantial market, it is evident that production costs will gradually decline. In that case, a four-seater version would certainly have a chance, provided a slightly more powerful engine is available.

What exactly is this engine on which the Microjet-200's entire operation depends? It is the TRS-18 which is actually a turbojet currently being mass-produced for altogether different requirements. In fact, the TRS-18 powers missiles being built in several countries. Thanks to the TRS-18, Microturbo is in a strong position to become the world's leading manufacturer in this field. In addition to French industrial firms, Microturbo's customers already include firms in the United States, the United Kingdom, and Australia.

The TRS-18's design is based on technological expertise gained in producing starters fro turbojet engines. These starters consist of small gas turbines spinning at nearly 50,000 rpm. They are standard equipment on, for example, all of the SNECMA [National Aircraft Engine Design and

Manufacturing Company] Atar gas turbine engines which power Mirage aircraft. Microturbo gradually shifted from the 50-to 150-horsepower starters to the 90- to 110- kilogram-thrust turbojet--namely the TRS-18, 200 of which have already been delivered--and then to the TRI-60, a turbojet generating 350 kilograms of thrust. The latter is also being mass-produced as the engine for target drone aircraft. A supersonic derivative of the TRI-60 is now under study, a development not very far removed from the cruise missile.

The TRS-18 starts and operates automatically. It weighs 37 kilograms, has a diameter of 30 centimeters, and rotates at 48,000 rpm. Its present service life is 350 hours, but it should be noted that this version is basically a missile engine! Its service life is being increased, however, to 1,000 hours. The TRS-18's main characteristics are its very great simplicity and exceptional ruggedness (one goes with the other). The most astonishing aspect of the TRS-18 "story" is the fact that aircraft manufacturers have been incredulous about the engine. At the present time, only three aircraft are powered by the TRS-18: a Swiss glider equipped with it as an auxiliary engine, an amateur aircraft derived from an American propeller-driven plane (and also built at Toulouse), and the Microjet-200. This situation is likely to change, however, as a result of the latter's test flights.

In such a highly active field as the aircraft industry, it is quite surprising to see an engine manufacturer obliged to become an aircraft manufacturer in order to demonstrate the serviceability of its engines! But one swallow, even a jet-propelled swallow, does not a summer make. So four other Microjet-200's are to be built. The wooden construction of the first model (used for reasons of economy) will be replaced by metal for the fuselage and composite materials for the wing and tail assembly. The first of these preproduction models is scheduled to make its initial flight by October 1981. The start of regular production will obviously depend on the reception this aircraft receives. It will participate in the next Farnborough and Paris air shows. But Microturbo is already looking for one or more partners.

What French or foreign manufacturers will seize the opportunity to be the first to mass produce the world's smallest jet aircraft?

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BRITISH AEROSPACE BAE 146 STATUS REPORT

Stuttgart FLUG REVUE in German Aug 80 pp 36-37

[Text] Seven years ago Hawker Siddeley announced Project HS 146. After the merger in 1977, the program survived on the back burner as British Aerospace BAe 146, until finally, in mid-1978, the green light was given to proceed with development and preparations for production. Now the first orders are in for this new British airliner.

The ice seems to be broken: after a long drought the first orders arrived a few weeks ago for the BAe 146. Lineas Aereas Privadas Argentinas (LAPA) submitted three firm orders and three options.

Rollo... of the first machine is set for late 1980, the maiden flight for spring 1981, and in addition to the cell intended for structural testing three machines are under construction. As with the Airbus program, major components are constructed at various works in England, Sweden and the United States and then freighted to Hatfield for final assembly. The nose and doors of the BAe 146 are built in Hatfield. The major components will arrive in the summer 1980 for final assembly of the first machine.

The British Aerospace works in England is responsible for building the fuselage, the wings are made at AVCO Aerostructures in Nashville, Tennessee, and the landing flaps, rudder and elevators at Saab-Scania in Sweden. The engines are four Avco Lycoming ALF 502R-3 fan jets, each delivering 3,040 kg thrust.

The first large component of the wings to be completed at AVCO Aerostructures Division in Nashville in February 1980 was the upper skin for the left wing, using a modern adhesive technique. In this process, the part is subjected to a pressure of 150 psi at a temperature of 150°C for 2 and 1/2 hours.

Registration of the BAe 146 is planned for 1982, followed by delivery of the first units to the airline companies. Delivery of 18 machines is planned by the end of 1982, in 1983 the rate of production will be three planes per month.

By spring 1980, British Aerospace had spent £ 70 million on the 146 program, with an additional £ 60 million earmarked before the year's end. Planning costs of the BAe 146 will total £ 230 million for British Aerospace alone; added to that are the amounts to be spent by Saab-Scania and AVCO Aerostructures, who joined the program as fully liable partners.

The 146 marketing team visited about 50 airline companies worldwide; perhaps 30 of them are considered good prospective buyers, and about 50 potential customers. In the first group there are some companies which place the greatest value on speedy delivery. According to cautious estimates, it is thought that about 320 units can be sold by 1992.

Initially the plane will be built in the 100 series, with a capacity of 70 to 90 passengers, the 200 stretch version, lengthened by 2.2 meters, can carry between 85 and 109 passengers. The possibility of being able to operate with this plane from unsurfaced or only partially surfaced runways, 1,000 to 1,200 meters long, the cabin comfort and the minimal demands on ground crews at small airports make the BAe 146 highly promising transportation for the years ahead.

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